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(54) IMPROVEMENTS IN OR RELATING TO VEHICLE ENGINE COOLING SYSTEMS

(71) I, THE SECRETARY OF STATE FOR DEFENCE, Whitehall, London, SW1A 2HB, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to a vehicle engine cooling system.

Vehicle engine cooling systems of conventional circulatory - fluid type are generally designed to have sufficient capacity to permit continuous removal of the maximum amount of heat that may be generated by the engine during peak load conditions. If these thermal peaks occur only infrequently as is often the case, average heat output rarely being more than 50% of peak heat output, the resulting cooling system is unnecessarily large for a considerable proportion of the full working cycle.

An object of the present invention is to provide a vehicle engine cooling system which can adapt to various cooling demands throughout the full working cycle of the engine so as to dissipate heat continuously at a relatively constant rate. Such a system may then be of a relatively small size, sufficient only for dissipating the average heat generated.

According to the present invention a vehicle engine cooling system having a circulatory transfer fluid for transporting heat from the engine to a first heat exchanger operative between the transfer fluid and atmosphere includes a second heat exchanger operative between the transfer fluid and a store material, the store material being selected to have a phase transition temperature within the temperature range imposed upon the transfer fluid by the engine.

The store material is able to absorb and store comparatively large amounts of heat at the phase transition temperature by virtue of its latent heat of fusion, i.e. the heat required to change from solid to liquid at the same temperature, or alternatively, its latent heat of vaporisation.

In operation, when the heat output of the engine is high and the first heat exchanger becomes heavily loaded, the temperature of the transfer fluid rises until it reaches the phase transition temperature of the store material, whereupon further heat input to the transfer fluid from the engine is rapidly absorbed from the transfer fluid by phase transition of the store material. The heat thus transferred to the store material is stored as latent heat of fusion or of vaporisation until such time as the heat output of the vehicle engine decreases permitting the transfer fluid temperature to fall below the phase transition temperature, thereby reversing the phase transition and releasing the stored heat back to the transfer fluid for normal transference to the atmosphere via the first heat exchanger.

The total heat storage capacity needed for a specific vehicle engine cooling system may be calculated from a knowledge of the peak and average output of the engine. A suitable store material is then selected, preferably having a phase transition temperature which is close to the average temperature imparted to the transfer fluid by the engine, and having a specific latent heat of fusion, or vaporisation, which is as high as possible. The higher the specific latent heat of the store material, the smaller the quantity that is required, and total weight is simply determined by dividing the necessary total storage capacity by the latent heat of fusion, or vaporisation, of the selected store material.

By way of example methyl fumarate, a material having a melting point of 102°C and a latent heat of fusion of 242kJ/Kg, is particularly suitable as a store material for the cooling system of a heavy duty vehicle operating in a hot climate.

Preferably the second heat exchanger has exchange surfaces arranged to be as extensive as possible to facilitate rapid heat exchange between the transfer fluid and the store material, and conveniently the exchange sufaces may be convoluted to define numerous thin platelets of the store material. Alternatively the transfer fluid may be circulated through an array of finned tubes, the spaces between the fins being packed with the store material. For example, a conventional vehicle engine radiator totally immersed in store material instead of in air would provide a heat storage matrix of suitably extensive exchange surface area.

Change of phase of the store material is of course accompanied by a change in volume and hence the heat storage matrix must be housed in an outer container which is capable of accomodating the volume change. The container may be flexible or alternatively, when a solid/liquid phase change is employed, the container may be vented to air. The volume change accompanying a solid/liquid phase change is less than that of a liquid/gas phase change and for this reason the choice of a store material to operate at its melting point is to be preferred.

An embodiment of the invention will now be described by way of example only, with reference to the Figures accompanying the provisional specification, of which

Figure 1 is a diagram of a vehicle engine cooling system including a part-longitudinal section of a heat storage matrix,

Figure 2 is a transverse section of the heat storage matrix taken on the line II-II of Figure 1 and

Figure 3 is an enlarged view of a portion of the heat storage matrix, sectioned at line III-III of Figure 2.

The heat storage matrix illustrated in Figures 1 and 2 comprises a distribution tank 1 into which circulating coolant or transfer fluid 9 flows, via an inlet pipe 2, from a conventional coolant circuit 12 of an engine 10 and associated air cooled radiator 11, which radiator constitutes the first heat exchanger. The transfer fluid 9 is distributed from the tank 1 into a parallel array of narrow tubes 3, which constitute the second heat exchanger, leading to a common collection tank 4 from whence the transfer fluid 9 is returned to the coolant circuit 12 via an outlet pipe 5.

The tubes 3 mutually bear a stack of heat transfer fins 6, perpendicularly arranged with respect to the tubes 3 and evenly spaced along the tube lengths. The complete matrix of tubes 3 and fins 6 together with the tanks 1 and 4 are totally embedded in a store material 7 contained in a flexible-walled container 8, the store material 7 being selected to have a phase transition temperature approximately equal to the mean running temperature of the coolant circuit 12. For example, methyl fumarate may be used for a system having a mean running temperature of about 102°C.

Embedment of the finned-tube matrix is of course readily achieved whilst the store material 7 is in its molten phase.

An enlarged section of the embedded matrix (Figure 3) illustrates the effect of heat transfer from the transfer fluid 9 via the tubes 3 and the fins 6 to the store material 7. The section is drawn to show the store material 7 in two co-existing phases, i.e. molten store material *7a* and solid store material *7b* having a common interface *7c*, which interface will be at the fusion temperature of the specific store material. As more heat is transferred to the store material from the transfer fluid, the interface *7c* will gradually recede from the surrounding heat transfer surfaces. When however transfer fluid entering the tubes 3 is at a lower temperature than the molten store material *7a* the heat transfer process is reversed, the molten store material *7a* gradually returning to the solid state (*7b*) and the disgorged heat being carried away by the transfer fluid 9 for disposal via the radiator 11.

It will of course be apparent that many other arrangements of a vehicle engine cooling system according to the present invention are possible, for example, the outer container of the heat storage matrix may itself be arranged to discharge heat to the vehicle body or to the air and may be further provided with internal fins, intrusive into the store material and regularly interspaced with the heat exchanger fins.

WHAT I CLAIM IS:-

1. A vehicle engine cooling sytem having a circulatory transfer fluid for transporting heat from the engine to a first heat exchanger operative between the transfer fluid and atmosphere, wherein a second heat exchanger operative between the transfer fluid and a store material is included, the store material being selected to have a phase transition temperature within the temperature range imposed upon the transfer fluid by the engine.

2. A vehicle engine cooling system as claimed in Claim 1 in which the store material has a phase transition temperature which is approximately equal to the mean temperature imparted to the transfer fluid by the engine.

3. A vehicle engine cooling system as claimed in Claims 1 and 2 in which the phase transition temperature of the store material is its vaporisation temperature.

4. A vehicle engine cooling system as claimed in Claims 1 and 2 in which the phase transition temperature of the store material is its fusion temperature.

5. A vehicle engine cooling system as claimed in Claim 4 in which the fusion temperature of the store material is greater than 0°C.

6. A vehicle engine cooling system as claimed in Claim 5 in which the fusion temperature of the store material is not less than 100°C.

7. A vehicle engine cooling system as claimed in Claim 6 in which the store material is methyl fumarate.

8. A vehicle engine cooling system as claimed in any one of Claims 1 to 7 wherein the store material is enclosed within a flexible outer container.

9. A vehicle engine cooling system as claimed in any one of Claims 4 to 7 wherein the store material is housed in a vented outer container.

10. A vehicle engine cooling system as claimed in any one of Claims 1 to 9 wherein the second heat exchanger includes one or more externally finned tubes intimately surrounded by the store material, through which tubes the transfer fluid is arranged to circulate.

11. A vehicle engine cooling system substantially as hereinbefore described with reference to the figures accompanying the provisional specification.

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FIG. 1.

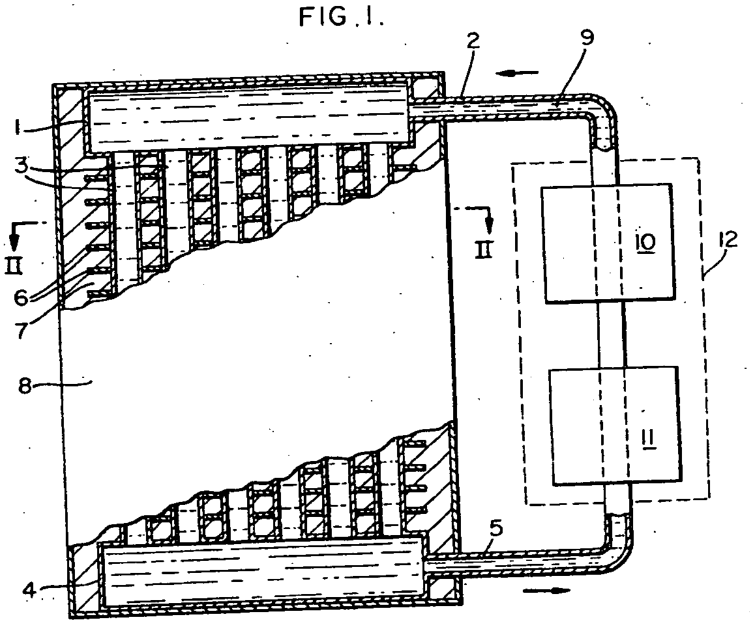

FIG. 2.

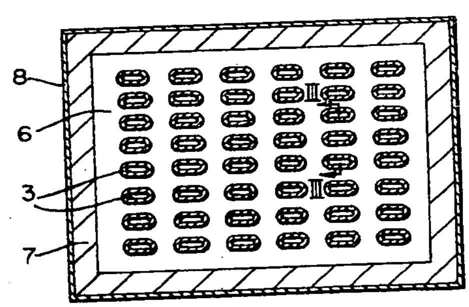

FIG. 3.